

**DEPARTMENT OF CONSERVATION**

DIVISION OF ADMINISTRATION

DIVISION OF MINES AND GEOLOGY

DIVISION OF OIL, GAS AND GEOTHERMAL RESOURCES

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February 27, 1998

Ms. Sandy Covall  
Emergency Services Coordinator  
Sonoma Operational Area  
Sonoma County  
2300 County Center Drive, Suite 221, Building A  
Santa Rosa, Ca 95403

RE: ENGINEERING GEOLOGIC REVIEW OF RIO NIDO LANDSLIDE, SONOMA  
COUNTY, CALIFORNIA

Dear Ms. Covall:

**INTRODUCTION**

A destructive landslide occurred in the Rio Nido residential area of Sonoma County in the evening of February 6, 1998. The Rio Nido area received prolonged and intense rainfall prior to the landslide. On February 7, 1998, the Department of Conservation (DOC), Division of Mines and Geology's (DMG) was requested by G. Harvey Smith of the Governors Office of Emergency Services (OES) to evaluate the impacts of the landslide, assess the potential for and magnitude of additional failures that may affect the residents of that community, and potential mitigation measures. DMG Headquarters in Sacramento responded that day by dispatching Wayne D. Haydon to the Sonoma County Emergency Operations Center (EOC) in Santa Rosa to coordinate with county and state officials dealing with the landslide. OES has assigned the Rio Nido Landslide a mission number of 98-CST7172. This report will present a brief review of the DMG investigations, conclusions and recommendations regarding the Rio Nido landslide.

**BACKGROUND**

The Rio Nido Landslide is about 2 miles northeast of Guerneville in northwestern Sonoma County. The landslide is in an east-facing drainage, west and upslope of Upper Canyon Three Road in the southwest corner of the U.S. Geological Survey

(USGS) Guerneville 7.5 minute topographic quadrangle. Figure 1 presents a location map of Rio Nido and vicinity and Figure 2 is a map of the Rio Nido Landslide. Russian River Fire Department Captain Dave Miinch, who was in the canyon when the landslide occurred, has indicated that the first small failure occurred at 10:35 pm on February 6, 1998 and that a larger failure occurred at 1:30 am on February 7. Three homes on the canyon floor have been destroyed and four homes have been damaged by the landslide. Residents were evacuated from the site following failure.

## SCOPE OF WORK

The scope of work of this review included: discussions with individuals named in this report; limited review of published pertinent geologic reports; limited interpretation of stereo aerial photographs of the site vicinity; field reconnaissance of the landslide and vicinity; briefing Sonoma County Sheriff's personnel on potential debris inundation areas; briefing the geologic consultant retained by Sonoma County; attendance and presentations at community meetings and press conferences, and preparation of this report.

On Saturday, February 7, 1998, Haydon and Dr. Tom Anderson of Sonoma State University conducted a helicopter overflight of the landslide and vicinity to observe the extent of the failure and assess the overall stability of the slopes adjacent to the landslide. On Sunday, February 8, Haydon, Anderson and Eric Mays, Sonoma County Supervisory Building Inspector, conducted a field reconnaissance of the landslide and the adjacent slopes. That evening Haydon and Sonoma County and state OES personnel attended community meetings at the Rio Nido Fire Station and Sebastopol Community Center, to brief residents of Rio Nido on the potential for, and magnitude of, additional failures that may affect the residents of that community and potential mitigation measures.

On Monday, February 9, Haydon briefed Pete Parkinson, Senior Planning Manager for Sonoma County, on the landslide. Parkinson requested Haydon to prepare a short report summarizing the geologic information acquired to date on the landslide.

On Tuesday, February 10, Haydon attended several meetings with OES and Sonoma County personnel to brief them on potential for, and magnitude of, additional failures and presented a preliminary written report to Parkinson (Haydon, 1998). Specifically, Haydon met with Harvey Smith, Sharon Leason and Steve Sellers of OES, Tom Schopflin the Sonoma County Administrator, National Guard Major Bill Clement and Jim Piccinini, the Sonoma County Sheriff, and Sheriff's staff on the landslide. That day, Haydon also met with Jim Leddy and Kathy Hayes, Field Representatives from Senator Mike Thompson, to brief them on the landslide. Haydon supplied Sonoma County with 350 copies of DMG Note 33 on mudslides for distribution to the residents. This publication has information on hazards of debris flows and landslides and how to recognize and reduce the risk from these slope failures.

Work with the Sonoma County Sheriff's staff consisted primarily of providing geologic information to be used in the Sheriff's plans to provide residents with temporary access to the evacuated areas: 1) a plan to allow evacuated residents of Upper Canyon Three to return to their homes for brief periods to retrieve pets and critical personal belongings; and 2) a plan to allow evacuated residents in Upper Canyon Three and Canyon Three to return to their homes for a long enough period to retrieve furniture and large appliances.

On Wednesday, February 11, Haydon attended a weather briefing conducted by the National Weather Service at the EOC. Following the briefing, Haydon conducted another field reconnaissance of the landslide with Mays and William McCormick, a geologist with Kleinfelder, the geotechnical consultant retained by Sonoma County, to determine if additional movement of the landslide had occurred.

On Thursday, February 12, Haydon attended a briefing at the EOC to discuss the observations made during the field reconnaissance of that day conducted by Mays and McCormick. Sonoma County personnel also requested Haydon to attend a press conference and community meeting on Friday, February 13.

## GEOLOGIC CONDITIONS

The Rio Nido area is underlain by interbedded sandstone and shale of the Rio Nido Terrane of the Franciscan Complex, Geologic Map symbol KJfss mapped by Huffman and Armstrong (1980) and Blake and others (1984) (see Figure 3 Geologic Map of the Rio Nido Landslide and Vicinity). The Rio Nido Terrane outcrops along the Russian River near Rio Nido and to the north as several deformed but relatively unmetamorphosed, sandstone-rich, fault-bounded belts of broken formation. In the vicinity of the landslide, these units strike generally east-west and dip 37 to 48 degrees to the north. Ridge lines near the landslide are generally stair stepped, consisting of alternating gently and more steeply sloping reaches. The sandstones generally underlie the steeper sloping portions of the ridges and the shales underlie the more gently sloping portions.

The sandstones and shales are red-brown, thick to thin bedded, intensely weathered, moderately weak, very intensely fractured and friable. Drainages underlain by the Franciscan Complex commonly accumulate loose and weak soil-like colluvium of varying thicknesses. The soils in the landslide vicinity have been mapped as the Hugo-Josephine complex soil series consisting of Hugo very gravelly loam and Josephine loam (Miller, 1972).

The drainage in which the landslide occurred was mapped by Huffman and Armstrong (1980) as containing an existing landslide, as were many of the other

drainages in the Rio Nido area (see Figure 4, Landslide and Relative Slope Stability Categories of the Rio Nido Landslide and Vicinity). Most of the mountainous terrain in the vicinity of the landslide has been mapped as Relative Slope Stability Category "C", described as "Areas of relatively unstable rock and soil units, on slopes greater than 15%, containing abundant landslides". The Franciscan Complex, in general, consists of relatively weak, broken rock. Areas underlain by these rocks and the accumulated colluvium are considered to be relatively unstable and contain abundant landslides.

## LANDSLIDE

The Rio Nido landslide is in a complex landslide, consisting of a rotational slump near the top of the ridge at an approximate elevation of 720 feet, and debris flows originating from the disaggregating toe of the rotational block. The debris flows moved downslope through a narrow drainage and ponded debris on the canyon floor, at an elevation of approximately 120 feet, destroying three homes and damaging four others. The total elevation drop of the landslide mass is about 600 feet (see Figure 2, Map of the Rio Nido Landslide). The vicinity of the landslide is heavily wooded with mature bay and Douglas fir trees with no indications of recent timber harvesting, grading or construction. No Timber Harvest Plans covering the landslide vicinity have been filed with the California Department of Forestry and Fire Protection (CDF) for the last 20 years. One Exemption was filed to remove one tree from the canyon floor (Tom Spittler, pers. comm.) but this would have no effect on slope stability.

Total width of the landslide headscarp is about 600 feet. The headscarp is arcuate in shape and was estimated to be about 30 feet high near its center during the February 8 field reconnaissance. The headscarp diminishes in height toward the north and south, until it disappears at the margins of the landslide. The bedrock material exposed in the headscarp consisted of intensely fractured and weathered sandstone typical of the Franciscan Complex.

Directly below the headscarp the rotational block has dropped (slumped) about 30 feet down the headscarp. This block has rotated down and to the east (displaced out of the slope) and tilted backwards, so the surface of the block now slopes slightly back into the slope. The rotational block varies between 100 and 200 feet in width. The field team was not able to ascertain the precise downslope extent of the rotational failure, but the thickness of the rotational block was estimated to be about 50 to 100 feet. Therefore the base of the rotational block is estimated to be at an elevation of about 600 to 650 feet. The rotational block has broken into a number of smaller blocks, especially near the eastern edge of the block. Each of the smaller blocks is separated from adjacent blocks by a scarp and/or grabens that trend roughly parallel to the headscarp or outward edge of the larger rotational block. The displacement on the

scarps and grabens are generally between a few inches and 4 feet at the time of the February 8 and 11 reconnaissance. Repeated reconnaissance of the rotational block conducted by Mays indicates the block has continued to break up, with displacements on the scarps and graben increasing and small failures occurring from the outside edge of the rotational block. This rotational block also has a dense canopy of trees, many of which are now tilting in various directions and leaning against each other as a result of the breakup of the larger block. Surface water is ponding on the rotational block directly below the headscarp.

A narrow unmapped trail or road was identified to the north and south of the landslide on the ridge above the landslide. This road was also identified on the rotational block and is crossed by the headscarp on the northern margin of the landslide. This road had a partial covering of forest litter and showed no signs of concentrated erosion such as rills or gullies. This road also is not redirecting surface runoff into the drainage containing the landslide.

In Haydon (1998) it was stated that the landslide consists of two parts - the main portion is a 500-foot-wide rotational block that has a debris flow at its toe, while a 100-foot-wide debris flow is located along the north margin of the rotational block. It was noted during subsequent field mapping that the rotational block extends across the entire width of the headscarp.

The debris flow source areas are on the eastern, displaced edge of the rotational block where the slope materials disaggregated and failed, flowing downslope to the canyon floor. The debris flow moved down two drainages. The southern, larger debris flow destroyed three homes and damaged four others on the west side of the canyon floor and deposited debris across to the east side of the canyon. The debris fan diverted the unnamed creek that flows down Upper Canyon Three to the east. During the February 8 and 11 reconnaissance, the creek was flowing in several new channels across the debris fan. Relatively clear surface water was observed flowing from springs in the debris flow source areas, becoming increasingly muddy as it flowed down the margins of this debris flow.

The smaller, northern debris flow moved directly east from the source areas down a shallow drainage, but did not reach the canyon floor. Muddy water was flowing from springs in the source area of the northern flow, down the drainage, and into the unnamed creek in Canyon Three.

## CONCLUSIONS

Based on the investigations conducted by DMG, the following conclusions were reached:

The Rio Nido Landslide is a complex landslide consisting of a rotational slump with debris flows that originated from the toe of the rotational slump and flowed down two drainages. It is estimated that the rotational block is about 50 to 100 feet thick. The estimated volume of the rotational block is about 140,000 to 250,000 cubic yards (yds) and the estimated volume of the material deposited on the canyon floor is about 20,000 to 30,000 yds. The southern debris flow mobilized and flowed down to the canyon floor, destroyed three homes and damaged four others, deposited a debris fan and diverted the creek. The northern debris flow moved eastward but did not reach the canyon floor. The cause of the landslide is interpreted to be the prolonged and intense rainfall in the Rio Nido area prior to the failure, falling on steep slopes with high relief, in an area underlain by relatively weak landslide prone rock, where landslides have occurred in the past. This rainfall has saturated the rock and colluvial material, reducing the material's strength and increasing its weight, until the material failed.

- 2) No man-induced causes of slope instability, such as timber harvesting or improper road construction were identified. The road or trail that crosses the rotational block and headscarp is interpreted as having no effect on the slope stability as there is no indication that this road is concentrating or redirecting drainage.
- 3) The primary future hazard from this landslide is the failure of the rest of the rotational block and the movement of this landslide material to the canyon floor where it can impact additional residences. While it is not possible to predict if and when the rotational block will fail, additional rainfall will most likely further destabilize the mass and increase the likelihood of a failure. The fact that the rotational block is already breaking up suggests that it may fail in pieces, reducing the amount of material delivered to the canyon floor at any one time. Failure of the maximum estimated volume of the rotational block (250,000 yds) in fluidized form, into the canyon with an approximately 200 foot width could likely inundate over a 1,000 feet of canyon floor. The area of the canyon which would likely be impacted by the worst case scenario could possibly extend to the southern end of Canyon Three, where Canyon Three Road and Willow Road intersect.
- 4) Following the February 8 reconnaissance, the area of the canyon most likely to be impacted by additional failures was interpreted to be Upper Canyon Three. Following the February 11 reconnaissance and Mays observation that the rotational block was continually breaking up, the worst-case scenario was interpreted to be the entire rotational block failing as a debris flow into the canyon.

- 5) A secondary future hazard is the debris flow material from additional failures flowing across the canyon floor, forming a landslide dam across the creek and the subsequent formation of a small lake behind the dam. Potentially this dam would fail, releasing the stored water and causing downstream flooding. The fluidized nature of the failed material will prevent the formation of a high dam, but will instead spread out creating a low wide dam. The fact that the rotational block is breaking up suggests that it may fail in pieces, reducing the amount of material delivered to the canyon floor at any one time and therefore reducing the volume of water stored behind the dam. As in conclusion 4 above, the worst-case scenario would be for the entire rotational block to fail as a debris flow into the canyon. Failure of the maximum estimated volume of the rotational block (250,000 yds) in fluidized form, into the canyon with an approximately 200 foot width could likely inundate over a 1,000 feet of canyon floor. Inundation from the water stored behind the landslide dam could affect areas upstream of the debris flows and downstream inundation from a dam failure would affect an even larger area than the debris flow.
- 6) Existing landslides have been mapped throughout Rio Nido and the vicinity and additional landslides may occur in other canyons of this area because rainfall and the geologic material are similar throughout the region.
- 7) These immediate hazards will likely persist until after the end of the rainfall season when water is no longer being infiltrated into the rotational block and the block has at least partially drained and temporarily stabilized. However, as long as the ground is saturated there is a potential for future movement. Failure of the block may also occur in response to earthquake shaking.
- 8) The rotational block will have to be mitigated to provide long term slope stability. Mitigation will likely include removal of the rotational block, and recontouring and revegetation of the slope.

## RECOMMENDATIONS

The following recommendations were made to Sonoma County and state OES personnel:

- 1) The Sonoma County Sheriff should consider the above conclusions in determining areas of evacuation and resident access, particularly in Upper Canyon Three and Canyon Three near the intersection of Canyon Three Road and Willow Road.

On February 10, it was recommended to Sonoma County and OES that a consultant be retained to monitor the displacement of the landslide, conduct an investigation to evaluate the geologic, hydrogeologic and geotechnical properties of the Rio Nido Landslide and evaluate the mitigation options. DMG recommended this investigation be conducted by a Certified Engineering Geologist and Registered Civil

- 2) or Geotechnical Engineer. In response to this recommendation, Sonoma County retained Kleinfelder as their consultant.
- 3) Sonoma County personnel and local residents of Rio Nido should consider monitoring for additional landslides that may occur in other canyons of this area.
- 4) Resident access for Plan 1, described under Scope of Work, should be conducted during periods when it is not raining. All personnel should stay off of the canyon floor and on the slopes on the east side of the canyon. No access should be allowed until after a geologist has reviewed the landslide displacement monitoring data, inspected the rotational block and concluded that the block is not currently moving and does not appear to be in imminent danger of failing. Personnel should be in place near the landslide, but not on the rotational block or in the debris flow channels, during the resident access to observe the rotational block and debris flow source areas. These personnel should be in radio contact with the personnel in the canyon to warn them if failures should occur from the block.
- 5) Resident access for Plan 2, as described under Scope of Work, should be conducted following periods when it has not rained for least 1 week. Access will have to be along the canyon floor to allow large enough trucks to transport the larger items. No access should be allowed until after a geologist has reviewed the landslide displacement monitoring data, inspected the rotational block and concluded that the block is not currently moving, spring flow from the rotational block and debris flow source areas has stopped and there does not appear to be an imminent danger of failing. Personnel should be in place near the landslide, but not on the rotational block or in the debris flow channels, during the resident access to observe the rotational block and debris flow source areas. These personnel should be in radio contact with the personnel in the canyon to warn them if failures should occur from the block.
- 6) No large scale mitigation work should be conducted on the landslide until the rotational block has drained and movement of the block has stopped. The consulting engineering geologist should decide when it is safe to begin work on stabilizing the landslide.
- 7) These recommendations should be updated by the consulting geologist prior to implementation to incorporate the most recent information on the stability of the landslide.

Ms. Sandy Covall  
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## REFERENCES

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- Huffman, M.E., and Armstrong, C.F., 1980, Geology for Planning in Sonoma County: California Division of Mines and Geology Special Report 120, 31 p., map scale 1:62,500.
- Miller, V.C., 1972, Soil Survey of Sonoma County, California, United States Department of Agriculture, Soil Conservation Service.

Wayne D. Haydon, CEG 1740  
Associate Engineering Geologist

Concur:

Date Trinda L. Bedrossian, CEG 1064  
Supervising Geologist

Attachments

cc: G. Harvey Smith, OES  
James Davis, State Geologist



### Geologic Map Explanation

- Uu Alluvium; sand, gravel, silt and clay  
Qs Older terrace deposits; sand, silt and gravel

### Geologic Symbols

- Khs Predominantly graywacke-type sandstone and shale with minor greenstone, conglomerate, chert, and breccium. Most pervasively shaly. Sandstone massive and well bedded to locally thin-bedded



Figure 3. Geologic map of Pine Ridge Landslide and vicinity. After Salasaga Landslide (Huffman and Armstrong, 1992).

### Landslide Map Explanation



Landslide: arrows show general direction of movement

### Relative Rock Stability Categories

#### Landslides

(see "Landslide Symbols" above)

Areas of normal relative slope stability. Failure and draw-type movements of open and soil have occurred, or may have occurred ("potential" landslides)

A

Areas of relatively unstable rock and soil units, on slopes greater than 15% containing abundant boulders.

B

Areas of relatively stable rock and soil units on slopes greater than 15% containing few boulders.

C

Areas of greatest relative stability due to low slope inclination - dominantly less than 15%.

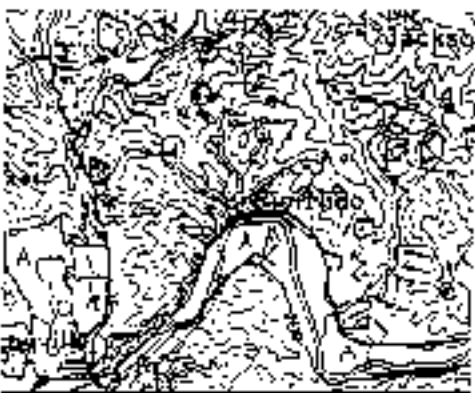
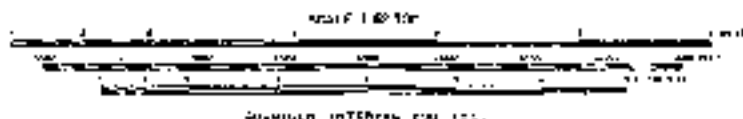


Figure 4. Mescal Landslide and Relative Rock Stability Categories of Rio Hato Landslide and vicinity (Huffman and Armstrong, 1992).



# Rio Nido Landslide

February, 1988

State Area Maps

Map No. 211 by the  
National Academy of Sciences  
Department of Geology  
University of Virginia

## Explanation

- Headscarp
- Rotational Block
- Debris Flow



Scale 1:50,000

1:50,000



GUERNEVILLE QUADRANGLE

U.S. GEOLOGICAL SURVEY  
BOLTON WEST QUADRANGLE

